In the Claims

1. (Amended) A method of optimizing the efficiency of a combustion device ~~such as a furnace, boiler, oven, or stove,~~ comprising at least <u>three</u> ~~one~~ control zone<u>s</u>, each of said control zones comprising at least one burner assembly, said method comprising:

a) individually supplying fuel to each of said burner assemblies in each of said control zones;

b) individually measuring a combustion characteristic of the collective combusted gas from said burner assemblies in each of said control zones; and

c) individually adjusting the flow of air to each of said burner assemblies in each of said control zones in response to the value of said combustion characteristic corresponding to each of said control zones to keep the value of each of said combustion characteristics within a predetermined range.

2. A method in accordance with claim 1 wherein said combustion characteristic comprises a component selected from the group consisting of oxygen concentration, carbon monoxide concentration, carbon dioxide concentration, and combinations thereof.

3. A method in accordance with claim 1 wherein said combustion characteristic is oxygen concentration.

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4. A method in accordance with claim 3 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the oxygen concentration in said collective combusted gas for each of said control zones is in the range of from about 0.5 to about 5.0 volume %, based on the total volume of said collective combusted gas.

5. A method in accordance with claim 3 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the oxygen concentration in said collective combusted gas for each of said control zones is in the range of from about 1.0 to about 3.0 volume %, based on the total volume of said collective combusted gas.

6. A method in accordance with claim 3 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the oxygen concentration in said collective combusted gas for each of said control zones is in the range of from 1.5 to 2.0 volume %, based on the total volume of said collective combusted gas.

7. A method in accordance with claim 1 wherein said combustion characteristic is carbon dioxide concentration.

8. A method in accordance with claim 7 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon dioxide concentration in said

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collective combusted gas for each of said control zones is greater than about 2.0 volume %, based on the total volume of said collective combusted gas.

9. A method in accordance with claim 7 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon dioxide concentration in said collective combusted gas for each of said control zones is greater than about 5.0 volume % , based on the total volume of said collective combusted gas.

10. A method in accordance with claim 7 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon dioxide concentration in said collective combusted gas for each of said control zones is greater than about 10.0 volume %, based on the total volume of said collective combusted gas.

11. A method in accordance with claim 1 wherein said combustion characteristic is carbon monoxide concentration.

12. A method in accordance with claim 11 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon monoxide concentration in said collective combusted gas for each of said control zones is less than about 1000 ppmv, based on the total volume of said collective combusted gas.

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13. A method in accordance with claim 11 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon monoxide concentration in said collective combusted gas for each of said control zones is less than about 500 ppmv, based on the total volume of said collective combusted gas.

14. A method in accordance with claim 11 wherein the step of individually adjusting the flow of air to each of said burner assemblies in each of said control zones of step c) is performed such that the carbon monoxide concentration in said collective combusted gas for each of said control zones is substantially 0 ppmv, based on the total volume of said collective combusted gas.

15. (Amended) A method of optimizing the efficiency of a combustion device ~~such as a furnace, boiler, oven, or stove,~~ comprising at least three ~~one~~ control zones, each of said control zones comprising at least one burner assembly, said method comprising:

a) individually supplying fuel to each of said burner assemblies in each of said control zones;

b) individually supplying primary air to each of said burner assemblies in each of said control zones for mixture and at least partial combustion with said fuel supplied thereto thereby producing a separate intermediate combustion product for each of said burner assemblies;

c) individually supplying secondary air to each of said burner assemblies in each of said control zones for mixture with said intermediate combustion product for further combustion thereby producing a combusted gas stream for each of said burner assemblies;

d) individually measuring a combustion characteristic of the collective combusted gas from said burner assemblies in each of said control zones; and

e) individually adjusting the flow of said primary air and individually adjusting the flow of said secondary air to each of said burner assemblies in each of said control zones in response to the value of said combustion characteristic corresponding to each of said control zones to keep the value of each of said combustion characteristics within a predetermined range.

16. A method in accordance with claim 15 wherein the flow of said primary air to each of said burner assemblies is adjusted in response to the value of said combustion characteristic corresponding to each of said control zones first, followed by adjustment of the flow of said secondary air, as needed, in order to keep the value of each of said combustion characteristics within said predetermined range.

17. A method in accordance with claim 15 wherein each of said combustion characteristics comprises a component selected from the group consisting of oxygen concentration, carbon monoxide concentration, carbon dioxide concentration, carbon dioxide concentration, and combinations thereof.

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18. A method in accordance with claim 15 wherein said combustion characteristic is oxygen concentration.

19. A method in accordance with claim 18 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the oxygen concentration of said collective combusted gas corresponding to each of said control zones is in the range of from about 0.5 to about 5.0 volume %, based on the total volume of said collective combusted gas.

20. A method in accordance with claim 18 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the oxygen concentration of said collective combusted gas corresponding to each of said control zones is in the range of from about 1.0 to about 3.0 volume %, based on the total volume of said collective combusted gas.

21. A method in accordance with claim 18 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the oxygen concentration of said collective combusted gas corresponding to each of said control zones is in the range of from 1.5 to 2.0 volume %, based on the total volume of said collective combusted gas.

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22. A method in accordance with claim 15 wherein said combustion characteristic is carbon dioxide concentration.

23. A method in accordance with claim 22 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the carbon dioxide concentration of said collective combusted gas corresponding to each of said control zones is greater than 2.0 volume %, based on the total volume of said collective combusted gas.

24. A method in accordance with claim 22 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the carbon dioxide concentration of said collective combusted gas corresponding to each of said control zones is greater than about 5.0 volume % , based on the total volume of said collective combusted gas.

25. A method in accordance with claim 22 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the carbon dioxide concentration of said collective combusted gas corresponding to each of said control zones is greater than 10.0 volume % , based on the total volume of said collective combusted gas.

26. A method in accordance with claim 15 wherein said combustion characteristic is carbon monoxide concentration.

27. A method in accordance with claim 26 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the carbon monoxide concentration of said collective combusted gas corresponding to each of said control zones is less than about 1000 ppmv, based on the total volume of said collective combusted gas.

28. A method in accordance with claim 26 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that the carbon monoxide concentration of said collective combusted gas corresponding to each of said control zones is less than about 500 ppmv, based on the total volume of said collective combusted gas.

29. A method in accordance with claim 26 wherein the step of individually adjusting the flow of said primary air and of individually adjusting the flow of said secondary air to each of said burner assemblies of step e) is performed such that said carbon monoxide concentration of said collective combusted gas corresponding to each of said control zones is substantially 0 ppmv, based on the total volume of said collective combusted gas.

30. (Amended) A combustion device comprising:

a) at least three ~~one~~ control zones, each of said control zones comprising at least one burner assembly;

b) at least one gas analyzer operably related to each of said control zones for receiving and analyzing samples of combusted gas from said control zones;

c) each of said burner assemblies comprising:

i) a fuel introduction means for introducing fuel into said burner assembly;

ii) a primary air introduction means for introducing primary air into said burner assembly for mixture and at least partial combustion with said fuel, thereby producing an intermediate combustion product; and

iii) a secondary air introduction means for introducing secondary air into said burner assembly for mixture and further combustion with said intermediate combustion product, thereby producing a combusted gas stream for each of said burner assemblies; and

d) control means operably related to said primary air introduction means, said secondary air introduction means, and said at least one gas analyzer, for adjusting the flow of primary air and the flow of secondary air to each of said burner assemblies in each of said control zones through said primary air introduction means and said secondary air introduction means, respectively, in response to the value of a combustion

characteristic measured in the collective combusted gas streams corresponding to each of said control zones.

31. A combustion device as recited in claim 30 wherein said primary air introduction means comprises an adjustable primary air register and said secondary air introduction means comprises an adjustable secondary air register.

32. A combustion device as recited in claim 30 wherein said combustion characteristic is oxygen concentration.

33. A combustion device as recited in claim 30 wherein said combustion characteristic is carbon monoxide concentration.

34. A combustion device as recited in claim 30 wherein said combustion characteristic is carbon dioxide concentration.

35. A method of increasing the efficiency of a combustion device comprising the following steps:

a) providing the combustion device of claim 30

b) introducing fuel into each of said burner assemblies in each of said control zones via said fuel introduction means;

c) introducing primary air into said burner assemblies in each of said control zones via said primary air introduction means for mixture and at least partial combustion with said fuel thereby producing an intermediate combustion product;

d) introducing secondary air into said burner assemblies in each of said control zones via said secondary air introduction means for mixture and further combustion with said intermediate combustion product thereby producing a combusted gas stream for each of said burner assemblies;

e) individually measuring the value of a combustion characteristic in the collective combusted gas streams corresponding to each of said control zones;

f) adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies in each of said control zones through said primary air introduction means and said secondary air introduction means, respectively, in response to the value of said combustion characteristics measured in step e) corresponding to each of said control zones.

36. A method in accordance with claim 35 wherein the flow of said primary air to each of said burner assemblies in each of said control zones is adjusted via said control means in response to the value of said combustion characteristic corresponding to each of said control zones first, followed by adjustment of the flow of said secondary air, as needed, via said control means in order to keep the value of each of said combustion characteristics within a predetermined range.

37. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the oxygen concentration in the

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collective combusted gas for each of said control zones is in the range of from about 0.5 to about 5.0 volume %, based on the total volume of said collective combusted gas.

38. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the oxygen concentration in the collective combusted gas for each of said control zones is in the range of from about 1.0 to about 3.0 volume %, based on the total volume of said collective combusted gas.

39. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the oxygen concentration in the collective combusted gas for each of said control zones is in the range of from 1.5 to 2.0 volume %, based on the total volume of said collective combusted gas.

40. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon dioxide concentration in the collective combusted gas for each of said control zones is greater than about 2.0 volume %, based on the total volume of said collective combusted gas.

41. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon dioxide concentration in

the collective combusted gas for each of said control zones is greater than about 5.0 volume % , based on the total volume of said collective combusted gas.

42. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon dioxide concentration in the collective combusted gas for each of said control zones is greater than 10.0 volume % , based on the total volume of said collective combusted gas.

43. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon monoxide concentration in the collective combusted gas for each of said control zones is less than about 1000 ppmv, based on the total volume of said collective combusted gas.

44. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon monoxide concentration in the collective combusted gas for each of said control zones is less than about 500 ppmv, based on the total volume of said collective combusted gas.

45. A method in accordance with claim 35 wherein the step of adjusting the flow of said primary air and the flow of said secondary air to each of said burner assemblies of step f) is performed such that the carbon monoxide concentration in

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the collective combusted gas for each of said control zones is substantially 0 ppmv, based on the total volume of said collective combusted gas.

46. An apparatus suitable for analyzing combusted gas from a combustion device comprising a moveable cart physically supporting the following components:

a) a combusted gas probe;

b) a free water knock-out vessel;

c) a vacuum pump;

d) a cooler containing a condenser and a condensed water knock-out vessel;

e) a combusted gas analyzer;

wherein said free water knock-out vessel is connected in fluid flow communication with said combusted gas probe and with said vacuum pump, said vacuum pump is connected in fluid flow communication with said condenser of said cooler; said condenser is connected in fluid flow communication with said condensed water knock-out vessel; and wherein said condensed water knock-out vessel is connected in fluid flow communication with said combusted gas analyzer.

47. A method in accordance with claim 1 wherein said measuring of each of said combustion characteristics of step b) is performed using the apparatus of

claim 46; wherein said combusted gas probe is operably related to said combustion device for receiving combusted gas from said combustion device.

48. A method for analyzing combusted gas from a combustion device comprising:

a) supplying the apparatus of claim 46;

b) introducing a combusted gas stream from said combustion device to said free water knock-out vessel via said combusted gas probe;

c) permitting free water in said combusted gas stream to separate from the combusted gas stream for removal from said free water knock-out vessel;

d) passing said combusted gas stream to said vacuum pump;

e) passing said combusted gas stream to said condenser of said cooler for condensation of at least a portion of the combusted gas stream thereby forming a liquid phase and a gas phase which are passed to said condensed water knock-out vessel for separation; and

f) removing said liquid phase from said condensed water knock-out vessel and passing said gas phase to said combusted gas analyzer for analysis.